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ABSTRACT

The nature and use of LISREL (LInear Structural RELationships) analysis are considered, including an examination of college students' commitment to a university. LISREL is a fairly new causal analysis technique that has broad application in the social sciences and that employs structural equation estimation. The application examined in this paper involves an aspect of Tinto's model of college student attrition: students' commitment to an institution. Data were obtained from a persistence study of first-year students at a major public university. During the first week of classes, students provided information on their background, their motivation for enrolling in school, and their commitment to the institution. Two months later, students were surveyed again concerning their commitment to the school and their activities on campus. The analysis involves a measurement model and structural equations model. The measurement variables: "peer relationships," "residency," and "social activities" are each expressed as some multiplier times the latent construct "social integration." The structural equations model specifies the causal relationships among exogenous variables (e.g., age and ethnicity) and endogenous variables (e.g., initial institutional commitment). (SW)

Introduction to LISREL: A Demonstration Using Students' Commitment to an Institution

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Abstract

Introduction to LISREL: A Demonstration Using Students' Commitment to an Institution

This is a research methods presentation which offers an introduction to LISREL, a relatively new causal analysis technique employing structural equation estimation. LISREL has a wide range of applications in the social sciences. A brief introduction to LISREL will be made. A LISREL analysis of students' commitment to a university will be presented and discussed.

Introduction to LISREL: A Demonstration Using Students' Commitment to an Institution

The purpose of this session is to introduce participants to LISREL, a causal analysis technique which is relatively new and which has broad application in the social sciences. I am assuming that participants have a basic knowledge of multiple regression and at least a familiarity with path analysis.

Introduction to LISREL

The acronym LISREL was taken from a description of the function of a statistical package, the analysis of LInear Structural RELationships among quantitative variables. This program has become so important in econometrics, psychometrics, and other social sciences that LISREL has come to stand both for a statistical package and an approach to data analysis.

Structural equations have been used extensively in the social and behavioral sciences. Analytic techniques associated with structural equations include simultaneous equation systems, linear causal analysis, path analysis, dependence analysis, etc. These models specify phenomena under study in terms of cause and effect variables and their indicators.

One problem with using such techniques of analysis in the social and behavioral sciences is that the assumptions are very restrictive. Basic assumptions for path analysis include:

1) relationships are linear, additive and causal,

2) residuals are not correlated among themselves,

3) the causal flow is unidirectional,

4) variables are measured on at least an interval level scale, and

5) variables are measured without error

(Pedhazur, 1982).

In actuality these assumptions are rarely met. For instance, the type of example presented later is usually analyzed using multiple regression or path analysis. Even though, for the problem presented, three assumptions, that residuals are not intercorrelated, that variables are measured on at least an interval scale and that variables are measured without error, are not met. Within LISREL such restrictive assumptions do not have to be met. In fact, of the five restrictive assumptions applying to path analysis only one must be retained for LISREL analysis: relationships among the variables are linear, additive and causal. Therefore, LISREL is particularly well suited to the types of analysis frequently needed in higher education research.

LISREL analysis is based upon regression analysis and analysis of variance but is far more complex. The subroutine simultaneously estimates unknown coefficients in a set of linear structural equations. The variables in the system may be directly observable variables or latent variables. The model assumes causality among latent variables which are in turn underlying causes of observed variables (Joreskog and Sorbom, 1984; Pedhazur, 1982).

In the most general form the LISREL model assumes a specified causal structure among a set of latent variables or hypothetical constructs, some of which are dependent or endogenous variables and others of which are independent or exogenous.

Upon application of LISREL to a given set of data theoretically motivated constraints may be placed upon specific portions of the model to test hypotheses regarding relationships among variables. By constraining factors (restricting them to certain values) and then comparing the chi-square for the resulting model with the chi-square for the unconstrained model one can determine the statistical significance resulting from the constraint (Benin and Johnson, 1984).

Additionally, examination of residuals, modification indices and t-values for individual parameters (provided with the LISREL output) allows the researcher to determine possible improvements to the model through the introduction of new relationships among variables or the deletion of previously specified relationships which have proven statistically significant. Of course, such modifications to the model must be theoretically valid.

An Example

For a simplified presentation of LISREL, we will examine a portion of the Tinto model of college student attrition, namely, influences on students' commitment to an educational institution. This variable has been Tinto viewed the attrition process (Figure 1) as a series of changing commitments and experiences affecting students' integration and, ultimately, decisions to withdraw from or to continue in the institution. The underlying assumption of the model was that students enter an institution with certain specifiable background characteristics and a measurable level of initial commitments. Within the institution, students engage in interactions with the environment during which they become integrated into the system both academically and socially.

In addition to these clearly distinguished realms of activity, academic and social, the model incorporated such factors as family background, individual attributes and pre-college schooling. Interactions between individuals and the academic and social systems of their college continually acted to modify goals and institutional commitments in ways which led to persistence or to varying forms of dropout. Theoretically, for two students of similar backgrounds and the same levels of initial commitments, a higher degree of integration into the system for one would mean greater subsequent commitment to the institution and to the goal of college completion.

Students' commitment to an institution has been a consistently strong predictor of subsequent persistence or attrition. Background characteristics (mostly demographic),

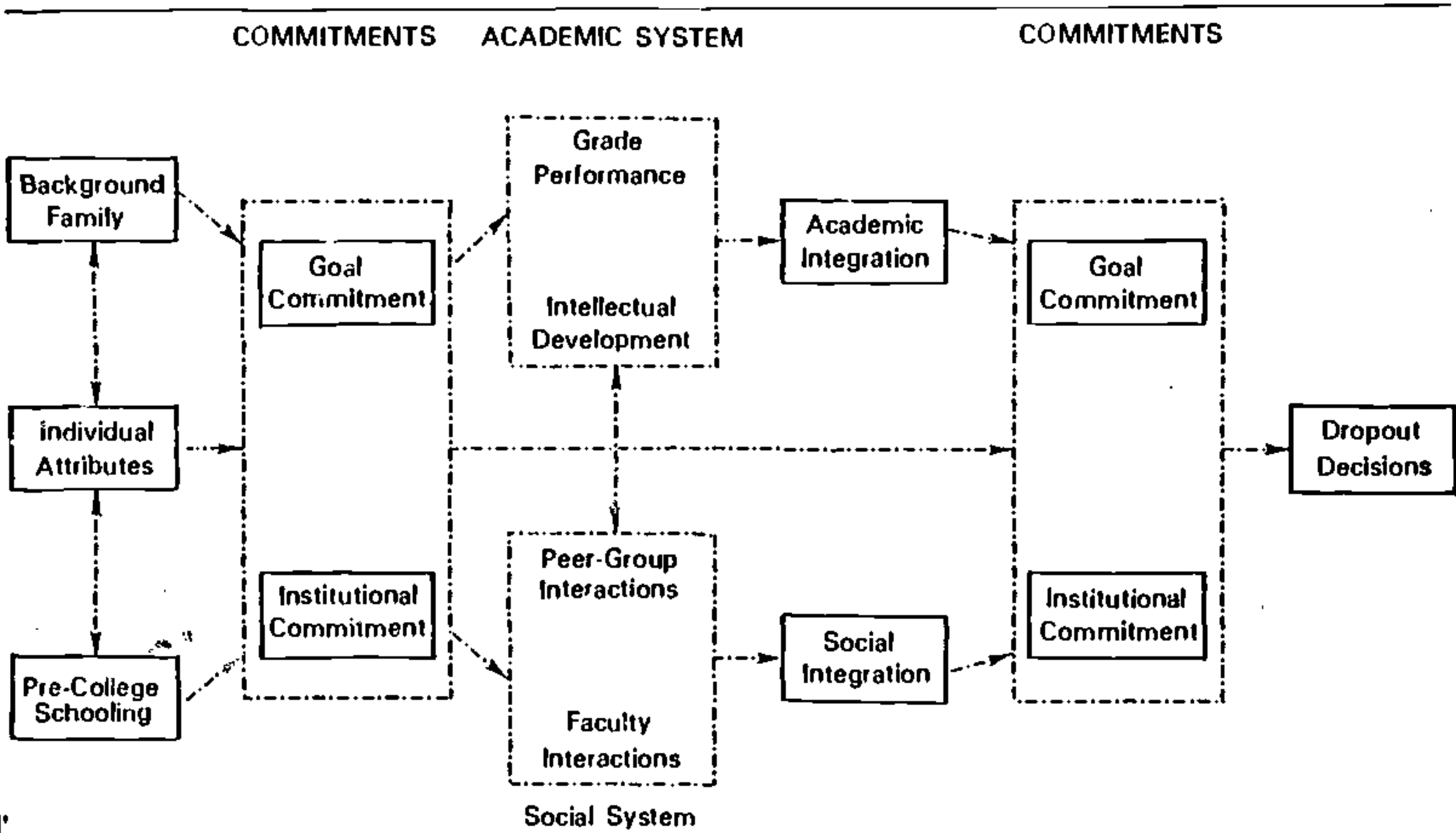

Figure 1. A conceptual schema for dropout from college. (From "Dropout from higher education: A theoretical synthesis." by V. Tinto, Review of Educational Research, 1975, 45, 89-125.)

level of institutional commitment upon arrival at the institution and social experiences at that institution have all significantly influenced later institutional commitment (Pascarella and Chapman, 1983; Tinto, 1982). The structural relationships of this portion of the model which we will examine are depicted in Figure 2.

Data Collection

The data used in this example were part of a persistence study and were collected from 316 first year students attending a major public university. In most attrition studies which used the Tinto model, attrition ranged from 8-11% during the first year. Attrition at the institution under study was very high. Typically 9-12% of the first year students dropped out during the first semester. Therefore a semester-to-semester study was conducted to attempt to determine why students left so early in their first year. Among the students in this sample the one semester attrition rate was 9%.

Students were surveyed during the first week of classes in the Fall 1984 semester. Students provided demographic information, answered questions concerning their motivation for enrolling in college [Educational Participation Scales (EPS), Boshier, 1982] and responded to questions regarding commitment to the university [Institutional Integration Scales (IIS), Pascarella and Terenzini, 1983]. Two months into the semester students were surveyed again using the complete IIS along with

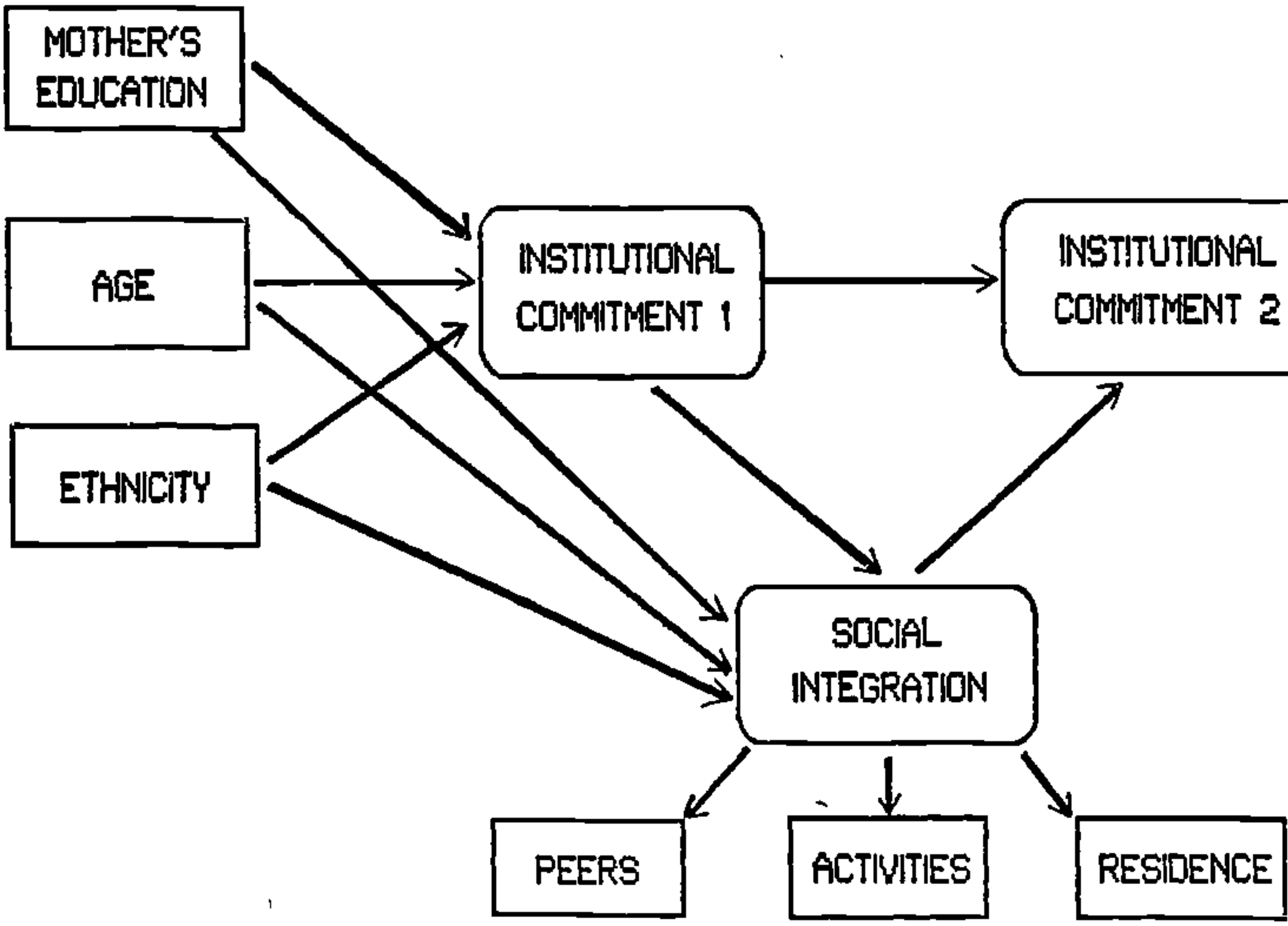

Figure 2. A ~~Modified~~ Model of Institutional Commitment

questions regarding their activities on campus. Identification numbers were used to match surveys and to obtain GPA, hours earned and registration information from institutional records. Measurement of the variables used in the persistence study is presented in Table 1. Social Integration was measured using the following indicators: Peer Relationships (a scale on the IIS), Residency (1=off campus, 2=off campus with other students, 3=on campus), and Social Activities (average number of hours per week spent engaged in social activities.

Seventy-one (71.0%) of the students who received the initial questionnaire filled out both surveys and were successfully matched to the institutional data base. A comparison of characteristics of the sample and of all new first year students is presented in Table 2.

For the overall persistence study, students were categorized according to their motivations for enrolling in the university using the EPS. The factor analysis and categorization of students is reported elsewhere (Stage, 1987). The three largest subgroups of students Certification (n=150), Cognitive (n=72) and Community Service (n=38) were used for analysis in the persistence study. These three subgroups were also used for the present analysis. Mean scores for each of the three subgroups on the variables of interest here are shown in Table 3.

TABLE 1

Measurement of Variables

Background Characteristics:

Mother's Education: 1 = < 12 years
2 = high school graduate
3 = 2 years college
4 = Bachelors degree
5 = Graduate or Professional School

Father's Education: 1 = < 12 years
2 = high school graduate
3 = 2 years college
4 = Bachelors degree
5 = Graduate or Professional School

Age

Sex: 1 = Female
2 = Male

Ethnicity: 0 = American Indian, Black, Chicano
1 = Anglo, Asian,Other

Goal Commitment (Time 1):
mean score on 3 items such as
It is important for me to graduate from college.
I have no idea at all what I want to major in.

Institutional Commitment (Time 1):
mean score on 5 items such as
It is imporant for me to be enrolled at Arizona State University.
It is likely that I will register at this University next fall.

Academic Integration:
Academic Development - mean score on 7 items such as -
I am satisfied with the extent of my intellectual development since enrolling in this university.
My academic experience has had a positive influence on my intellectual growth and interest in ideas.

Faculty Concern - mean score on 5 items such as -
Few of the faculty members I have had contact with are generally interested in students.
Few of the faculty members I have had are genuinely outstanding or superior teachers.

Table 1 (continued)

Academic Integration (continued)

GPA
Hours earned
Hours spent engaged in academic activities (band, theatre, publications, professional clubs, etc.)

Social Integration:
Peer Group Relations - mean score on 7 items such as -
Since coming to this university I have developed close personal relationships with other students.
The student friendships I have developed at this university have been personally satisfying.

Informal Faculty Relations - mean score on 5 items such as -
My nonclassroom interactions with faculty have had a positive influence on my personal growth, values and attitudes.
My nonclassroom interactions with faculty have had a positive influence on my career goals and aspirations.

Residency:	1 = off campus
	2 = off campus with other students
	3 = on campus
Campus Employment:	1 = yes
	2 = no

Hours spent engaged in social activities (intramurals, sororities, fraternities, social clubs, residence hall activities, etc.)
Hours spent engaged in intercollegiate athletics

Institutional Commitment (Time 2): same measures as shown on previous page
Goal Commitment (Time 2): same measures as shown on previous page

Persistence:	0 = not registered for spring semester
	1 = registered for spring semester

Table 2.

Characteristics of the Sample

Compared with All Freshmen

Characteristic	Sample	Freshmen
Females	57.5%	49.0%
Minorities	9.9%	9.3%
Age	18.01	19.10
Mean GPA	2.44	2.20
Mean Credits Earned	12.20	11.33
% Persistence to Spring '85	91.0%	87.9%

Variable	Certification (n=172)	Cognitive (n=82)	Community Service (n=38)
BACKGROUND:			
Mother's Education (a)	2.947	2.931	3.079
Age	18.033	18.097	17.921
Ethnicity(% maj.)	90.7	91.7	86.8
Institutional Commitment1 (a)	4.171	4.253	4.132
SOCIAL INTEGRATION:			
Peer Relations (a)	3.550	3.542	3.823
Activities	6.037	6.042	4.684
Residency (b)	2.113	2.181	2.579
Institutional Commitment2	3.851	3.880	3.921
PERSISTENCE (%)	94.5	88.9	88.9

(a) scale from 1 to 5
(b) 1=on campus,2=off campus with students,3=off campus

Table 3. Means Scores by Motivational Orientation Subgroup

Specification of the Model

In the model the demographic indicators, Mother's Education, Age and Ethnicity are, as in path analysis, the exogenous variables (Figure 2). They are unexplained in the analysis but are used to explain later variables. By contrast, Initial Institutional Commitment, Social Integration and Later Institutional Commitment are endogenous variables. The purpose of this analysis (again as in path analysis) is to explain the variance in these variables. Initial and Later Institutional Commitment are manifest variables (measured directly). Social Integration is a latent variable with multiple indicators.

Actual analysis consists of two distinct types which are approximated simultaneously: the measurement model and the structural equations model. The measurement model specifies how the latent variables are measured in terms of the observed variables. The structural equations model specifies the causal relationships among the exogenous and endogenous variables.

In this study the measurement model for observed y can be written:

$$y = \Lambda_y \eta + E$$

where the observed y_i are determined by a multiplier (Λy_i) times the latent construct (η) plus error (E_i). For example, in this study the set of measurement variables, Peer Relationships, Residency and Social Activities are each expressed as some multiplier times the latent construct Social Integration (β) plus some degree of error.

The structural equations model specifies the causal relationships among exogenous variables (Mother's Education, Age and Ethnicity) and endogenous variables (Initial Institutional Commitment, Social Integration and Later Institutional Commitment). In matrix form the general structural equation is:

$$\eta = \beta\eta + \Gamma\xi + \zeta$$

where each endogenous construct (η_i) may be related to other endogenous variables (η) and exogenous variables (ξ) plus some degree of error (ζ_i). Table 4 demonstrates the measurement of the latent constructs. With one exception, the construct or latent variables are measured directly using one indicator. Social Integration, as indicated, is measured using three variables, peer relationships, social activities and campus residency.

The structural equations to be solved within LISREL are specified in matrix form. A subroutine makes a preliminary evaluation of the data and, using two stage least squares (usually), generates an initial solution which, ideally, is very close to the optimal solution. Incremental changes are then made simultaneously by the program to paths specified in the model and after several iterations, a maximum likelihood solution is arrived at.

Latent Constructs	LISREL Variable	Observed Variables
Exogenous:		
Mother's Education	$\Gamma_1 = X_1$	Mother's Education
Age	$\Gamma_2 = X_2$	Age
Ethnicity	$\Gamma_3 = X_3$	Ethnicity
Endogenous:		
Instit. Commitment 1	$\eta_1 = y_1$	Instit. Commit. 1
Social Integration	$\eta_2 =$	
	y_2	Peer Relationships
	y_3	Social Activities
	y_4	Campus Residency
Instit. Commitment 2	$\eta_3 = y_5$	Instit. Commit. 2

Table 4. Measurement of the Latent Constructs

Matrices

A researcher specifying a LISREL model must identify the relationship between each pair of variables in the model as none, correlated or causal. Four matrices are used to specify causation within the model, Lambda-X, Lambda-Y, Beta, and Gamma. Additionally, four other matrices, Phi, Psi, Theta-delta, and Theta-epsilon are used to specify relationships between pairs of variables which may be correlated but which have no specified causal link. In order to limit the amount of information presented, these error matrices will not be discussed here.

Figure 3 presents the specification for this particular model. Lambda-X specifies the measurement of the exogenous variables; here the matrix is the identity because only one indicator is used to measure each construct. Lambda-Y specifies measurement of the endogenous variables. This matrix is similar to the identity matrix but in the second column three indicators of Social Integration are specified. One of these three indicators is fixed to a value of one in order to assign a relative unit of measurement for the latent variable. Beta specifies relationships among the endogenous variables; a non-zero entry (free - the value is free to be estimated) indicates that the construct at that top of the column is causally related to the construct at the beginning of that row. Gamma specifies relationships between exogenous and endogenous constructs. Again, a non-zero entry indicates that the construct at the top of that column is causally related to the construct at

		Mother's Ed	Age	Ethnicity
	Mother's Ed	1	0	0
Lambda-x	Age	0	1	0
	Ethnicity	0	0	1

		InstCom1	Socl Int	InstCom2
	InstCom1	1	0	0
	Peers	0	1	0
Lambda-y	Activities	0	free	0
	Residency	0	free	0
	Instcom2	0	0	1

		InstCom1	Socl Int	InstCom2
	InstCom1	0	0	0
Beta	Socl Int	free	0	0
	InstCom2	free	free	0

		Mother's Ed	Age	Ethnicity
	InstCom1	free	free	free
Gamma	Socl Int	free	free	free
	InstCom2	0	0	0

Figure 3. Matrix specification for LISREL.

the beginning of that row.

Through a shorthand for control cards and parameters, lines of the LISREL program are used to specify matrices (Table 5). For example, line 10 of the program fixes to zero the first second and third elements of the third row of Gamma. This specifies that Mother's Education, Age, and Ethnicity have no direct effect on Later Institutional Commitment. Line 11 of the program frees the second element of row three and the second element of row four. In other words the program will provide an estimate of the causal relationship between Social Integration and Activities and between Social Integration and Residency. For a complete understanding of the parameters, the LISREL manual should be read (Joreskog and Sorbom, 1984).

The LISREL program generates a wide range of output. Default output includes parameter specifications, the matrix to be analyzed, the initial estimates, the LISREL estimates and the overall goodness of fit measures. Other output which may be requested includes standard errors, t-values, total effects, modification indices and standardized solutions.

Results

Resulting LISREL estimates and modification indices for the Certification subgroup are presented in Tables ~~5~~ 6 & ~~6~~ 7. Modification indices can be used to make adjustments to the model if care is taken to ensure that such modifications are theoretically sound. Values given represent approximate

```
CERTIF AND INSTITUTIONAL COMMITMENT
DATA NI=8  NO=150 NG=3
LA
*
*INSTCOM1* *PEERS* *ACTIV* *RESID* *INSTCOM2* *MED* *AGE* *ETHN*
KM
*
1
.293 1
.016 .166 1
.103 .376 .152 1
.622 .257 -.022 -.062 1
.096 .062 .148 .252 -.02 1
-.011 -.105 -.025 -.071 .014 -.107 1
-.182 -.076 .093 .101 -.222 -.040 -.107 1
MC NY=5 NX=3 NE=3 NK=3 LY=ID BE=SD GA=FR PH=ST TD=DI,FI PS=DI,FR TE=FU,FI
ST .5 BE 2 1-BE 3 2 LY 3 2 LY 4 2
VA 1 LY 1 1 LY 2 2 LY 5 3
FI PH 1 1 PH 2 2 PH 3 3
FI GA 3 1 GA 3 2 GA 3 3
FR LY 3 2 LY 4 2
FR TE 2 2 TE 3 3 TE 4 4
LE
*INSTCOM1* *SOCLINT* *INSTCOM2*
LK
*MED* *AGE* *ETHN*
OU RS MI TV
COGNITIV AND INSTITUTIONAL COMMITMENT
DATA NI=8  NO=072 MA=KM
LA
*
*INSTCOM1* *PEERS* *ACTIV* *RESID* *INSTCOM2* *MED* *AGE* *ETHN*
KM
*
1
.244 1
-.018 .174 1
.115 .345 .302 1
.496 .344 -.013 -.000 1
-.079 -.013 .156 .225 -.232 1
.088 .115 -.053 -.220 .173 -.179 1
.137 .156 -.062 .132 .051 -.047 .107 1
MC NY=5 NX=3 NE=3 NK=3 BE=PS LX=SP LY=PS GA=SP TD=SP PH=SP PS=SP TE=SP
VA 1 LY 1 1 LY 2 2 LY 5 3
LE
*INSTCOM1* *SOCLINT* *INSTCOM2*
LK
*MED* *AGE* *ETHN*
OU RS MI TV/
COMMUNITY SERVICE AND INSTITUTIONAL COMMITMENT
DATA NI=8  NO=038 MA=KM
LA
*
*INSTCOM1* *PEERS* *ACTIV* *RESID* *INSTCOM2* *MED* *AGE* *ETHN*
KM
*
1
.464 1
-.026 .236 1
.151 .442 .302 1
.730 .465 .045 .142 1
.115 .237 .158 .111 -.063 1
.245 .098 .062 .143 .117 -.065 1
.038 .165 .091 .147 .028 .013 -.077 1
MC NY=5 NX=3 NE=3 NK=3 BE=PS LX=SF LY=PS GA=SP TD=SF PH=SF PS=SF TE=SP
VA 1 LY 1 1 LY 2 2 LY 5 3
LE
*INSTCOM1* *SOCLINT* *INSTCOM2*
LK
*MED* *AGE* *ETHN*
OU RS MI TV
```

Table 5. LISREL Control Lines

CERTIF AND INSTITUTIONAL COMMITMENT

LISREL ESTIMATES (MAXIMUM LIKELIHOOD)

LAMBDA Y

	INSTCOM1	SOCLINT	INSTCOM2
INSTCOM1	1.000	.000	.000
PEERS	.000	1.000	.000
ACTIV	.000	.505	.000
RESID	.000	1.729	.000
INSTCOM2	.000	.000	1.000

BETA

	INSTCOM1	SOCLINT	INSTCOM2
INSTCOM1	.000	.000	.000
SOCLINT	.087	.000	.000
INSTCOM2	.649	-.297	.000

GAMMA

	MED	AGE	ETHN
INSTCOM1	.087	-.021	-.181
SOCLINT	.152	-.026	.068
INSTCOM2	.000	.000	.000

PHI

	MED	AGE	ETHN
MED	1.000		
AGE	-.167	1.000	
ETHN	-.040	-.107	1.000

PSI

INSTCOM1	SOCLINT	INSTCOM2
.955	.174	.595

THETA EPS

	INSTCOM1	PEERS	ACTIV	RESID	INSTCOM2
INSTCOM1	[illegible]				
PEERS	.000	.789			
ACTIV	.000	.000	.946		
RESID	.000	.000	.000	.371	
INSTCOM2	.000	.000	.000	.000	.000

W_A_R_N_I_N_G : THE MATRIX THETA EPS IS NOT POSITIVE DEFINITE

THETA DELTA

MED	AGE	ETHN
.000	.000	.000

SQUARED MULTIPLE CORRELATIONS FOR Y - VARIABLES

INSTCOM1	PEERS	ACTIV	RESID	INSTCOM2
1.000	.211	.054	.629	1.000

SQUARED MULTIPLE CORRELATIONS FOR X - VARIABLES

MED	AGE	ETHN
1.000	1.000	1.000

SQUARED MULTIPLE CORRELATIONS FOR STRUCTURAL EQUATIONS

INSTCOM1	SOCLINT	INSTCOM2
.341	.174	.405

TOTAL COEFFICIENT OF DETERMINATION FOR STRUCTURAL EQUATIONS IS .171

MEASURES OF GOODNESS OF FIT FOR THE WHOLE MODEL :

GOODNESS OF FIT INDEX IS .958

ROOT MEAN SQUARE RESIDUAL IS .069

Table 6. Maximum Likelihood Estimates for the Certification Subgroup

CERTIF AND INSTITUTIONAL COMMITMENT

MODIFICATION INDICES

LAMBDA Y

	INSTCOM1	SOCLINT	INSTCOM2
INSTCOM1	.000	.000	2.039
PEERS	10.544	.000	14.749
ACTIV	.149	.000	.063
RESID	8.353	.000	6.070
INSTCOM2	.000	.000	.000

BETA

	INSTCOM1	SOCLINT	INSTCOM2
INSTCOM1	.000	.000	1.088
SOCLINT	.000	.000	1.544
INSTCOM2	.000	.000	.000

GAMMA

	MED	AGE	ETHN
INSTCOM1	.000	.000	.000
SOCLINT	.000	.000	.030
INSTCOM2	.384	.010	2.183

PHI

	MED	AGE	ETHN
MED	.000		
AGE	.000	.000	
ETHN	.000	.000	.000

PSI

INSTCOM1	SOCLINT	INSTCOM2
.000	.000	.000

THETA EPS

	INSTCOM1	PEERS	ACTIV	RESID	INSTCOM2
INSTCOM1	2.039				
PEERS	.435	.000			
ACTIV	.027	1.001	.000		
RESID	1.529	2.366	2.532	.000	
INSTCOM2	2.039	6.554	.000	1.505	.000

THETA DELTA

MED	AGE	ETHN
.000	.000	.000

Table 7. Modification Indices for the Certification Subgroup

improvements to the chi-square value associated with the fit of the model to the data. Table ~~6~~ 7 indicates strong relationships between Peers and both Institutional Commitment 1 and Institutional Commitment 2 over and above the relationship already specified (jointly with activities and residency). The modification indices for the other two subgroups indicated similarly strong relationships. Because such a modification does not violate basic tenets of the Tinto theory, changes were made in the specification to free the effect of the variable Peers. The modified model of Institutional Commitment is presented in Figure 4.

Results for each of the three subgroups are presented in Tables ~~7~~ 8, ~~8~~ 9 & ~~9~~ 10. Significant effects (according to the t-values provided with the output) are indicated with asterisks.

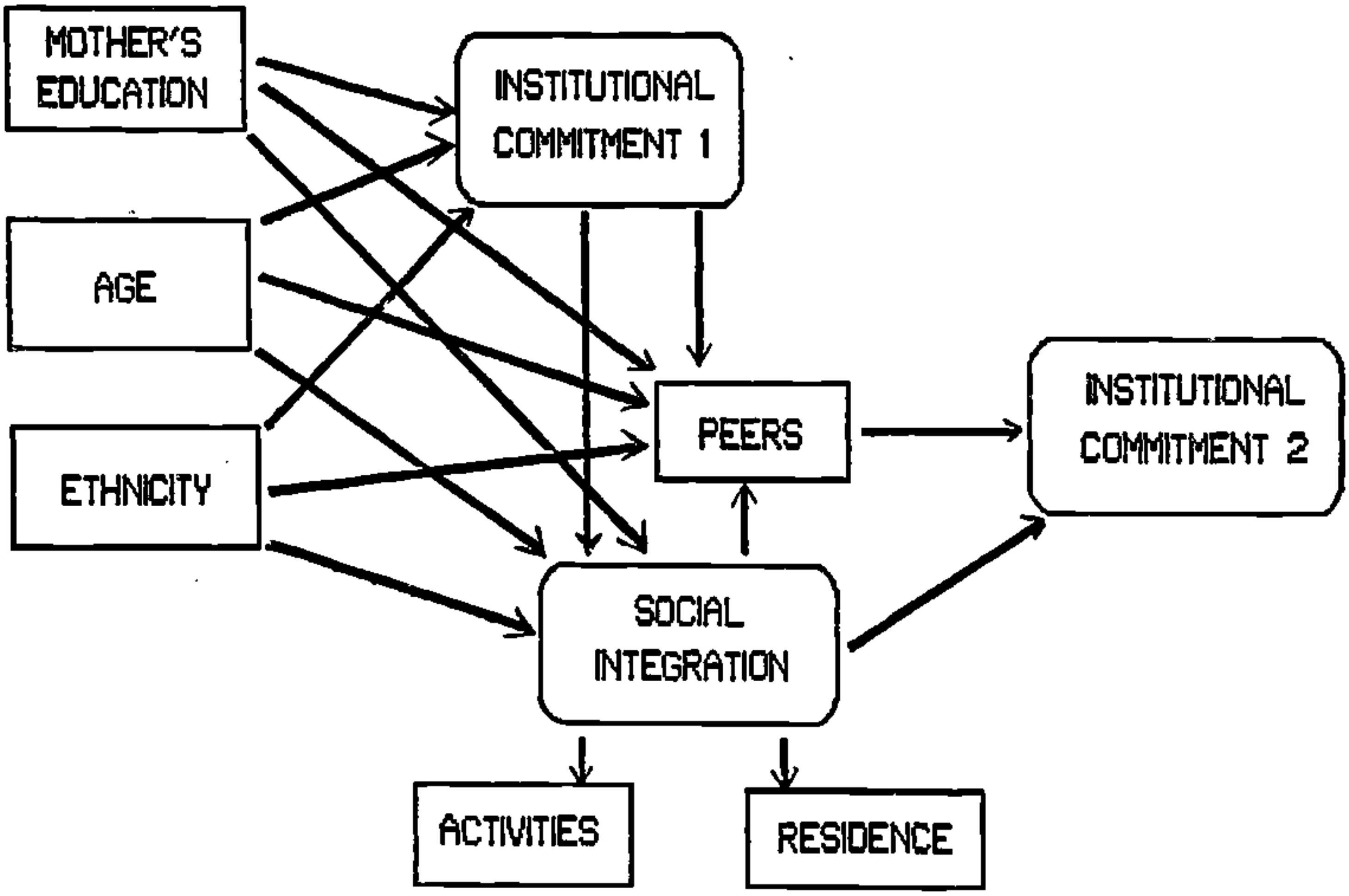

Figure ~~2~~ 4. A Modified Model of Institutional Commitment

CERTIF AND INSTITUTIONAL COMMITMENT

LISREL ESTIMATES (MAXIMUM LIKELIHOOD)

LAMBDA Y

	INSTCOM1	PEERS	SOCLINT	INSTCOM2
INSTCOM1	1.000	.000	.000	.000
PEERS	.000	1.000	.000	.000
ACTIV	.000	.000	1.000*	.000
RESID	.000	.000	2.234**	.000
INSTCOM2	.000	.000	.000	1.000

BETA

	INSTCOM1	PEERS	SOCLINT	INSTCOM2
INSTCOM1	.000	.000	.000	.000
PEERS	.177*	.000	2.463*	.000
SOCLINT	.043	.000	.000	.000
INSTCOM2	.550***	.266**	-1.084*	.000

GAMMA

	MED	AGE	ETHN
INSTCOM1	.027	-.021	-.181*
PEERS	-.276*	-.072	-.204*
SOCLINT	.121*	-.013	.069*
INSTCOM2	.000	.000	.000

PHI

	MED	AGE	ETHN
MED	1.000		
AGE	-.107	1.000	
ETHN	-.040	-.107	1.000

PSI

INSTCOM1	PEERS	SOCLINT	INSTCOM2
.955***	.528***	.062	.543***

THETA EPS

	INSTCOM1	PEERS	ACTIV	RESID	INSTCOM2
INSTCOM1	.000				
PEERS	.000	.000			
ACTIV	.000	.000	.917***		
RESID	.000	.000	.000	.566***	
INSTCOM2	.000	.000	.000	.000	.000

W_A_R_N_I_N_G : THE MATRIX THETA EPS IS NOT POSITIVE DEFINITE

THETA DELTA

MED	AGE	ETHN
.000	.000	.000

SQUARED MULTIPLE CORRELATIONS FOR Y - VARIABLES

INSTCOM1	PEERS	ACTIV	RESID	INSTCOM2
1.000	1.000	.083	.414	1.000

SQUARED MULTIPLE CORRELATIONS FOR X - VARIABLES

MED	AGE	ETHN
1.000	1.000	1.000

SQUARED MULTIPLE CORRELATIONS FOR STRUCTURAL EQUATIONS

INSTCOM1	PEERS	SOCLINT	INSTCOM2
.041	.472	.256	.457

TOTAL COEFFICIENT OF DETERMINATION FOR STRUCTURAL EQUATIONS IS .374

MEASURES OF GOODNESS OF FIT FOR THE WHOLE MODEL :

GOODNESS OF FIT INDEX IS .956

ROOT MEAN SQUARE RESIDUAL IS .015

* $p < .05$

** $p < .01$

*** $p < .001$

Table 9. Estimates for the Certification Subgroup (modified model)

COGNITIV AND INSTITUTIONAL COMMITMENT

LISREL ESTIMATES (MAXIMUM LIKELIHOOD)

LAMBDA Y

	INSTCOM1	PEERS	SOCLINT	INSTCOM2
INSTCOM1	1.000	.000	.000	.000
PEERS	.000	1.000	.000	.000
ACTIV	.000	.000	1.000*	.000
RESID	.000	.000	1.945**	.000
INSTCOM2	.000	.000	.000	1.000

BETA

	INSTCOM1	PEERS	SOCLINT	INSTCOM2
INSTCOM1	.000	.000	.000	.000
PEERS	.122	.000	1.705*	.000
SOCLINT	.059	.000	.000	.000
INSTCOM2	.443***	.387***	-.843	.000

GAMMA

	MED	AGE	ETHN
INSTCOM1	-.068	.063	.127
PEERS	-.168	.249*	.011
SOCLINT	.125*	-.095	.062
INSTCOM2	.000	.000	.000

PHI

	MED	AGE	ETHN
MED	1.000		
AGE	-.179	1.000	
ETHN	-.047	.107	1.000

PSI

INSTCOM1	PEERS	SOCLINT	INSTCOM2
.572***	.633***	.098	.231***

THETA EPS

	INSTCOM1	PEERS	ACTIV	RESID	INSTCOM2
INSTCOM1	.000				
PEERS	.000	.000			
ACTIV	.000	.000	.869***		
RESID	.000	.000	.000	.904**	
INSTCOM2	.000	.000	.000	.000	.000

W_A_R_N_I_N_G : THE MATRIX THETA EPS IS NOT POSITIVE DEFINITE

THETA DELTA

MED	AGE	ETHN
.000	.000	.000

SQUARED MULTIPLE CORRELATIONS FOR Y - VARIABLES

INSTCOM1	PEERS	ACTIV	RESID	INSTCOM2
1.000	1.000	.131	.496	1.000

SQUARED MULTIPLE CORRELATIONS FOR X - VARIABLES

MED	AGE	ETHN
1.000	1.000	1.000

SQUARED MULTIPLE CORRELATIONS FOR STRUCTURAL EQUATIONS

INSTCOM1	PEERS	SOCLINT	INSTCOM2
.428	.367	.252	.769

TOTAL COEFFICIENT OF DETERMINATION FOR STRUCTURAL EQUATIONS IS .393

MEASURES OF GOODNESS OF FIT FOR THE WHOLE MODEL :

GOODNESS OF FIT INDEX IS .986

ROOT MEAN SQUARE RESIDUAL IS .031

* $p < .05$

** $p < .01$

*** $p < .001$

Table 9. Estimates for the Cognitive Subgroup (modified model)

LISREL ESTIMATES (MAXIMUM LIKELIHOOD)

LAMBDA Y

	INSTCOM1	PEERS	SOCLINT	INSTCOM2
INSTCOM1	1.000	.000	.000	.000
PEERS	.000	1.000	.000	.000
ACTIV	.000	.000	1.000 *	.000
RESID	.000	.000	1.557	.000
INSTCOM2	.000	.000	.000	1.000

BETA

	INSTCOM1	PEERS	SOCLINT	INSTCOM2
INSTCOM1	.000	.000	.000	.000
PEERS	.261	.000	3.220	.000
SOCLINT	.653	.000	.000	.000
INSTCOM2	.533 *	.836	-2.278	.000

GAMMA

	MEC	AGE	ETHN
INSTCOM1	.135	.258	.056
PEERS	-.226	-.152	-.065
SOCLINT	.127	.052	.066
INSTCOM2	.000	.000	.000

PHI

	MEC	AGE	ETHN
MEC	1.000		
AGE	-.065	1.000	
ETHN	.013	-.077	1.000

PSI

INSTCOM1	PEERS	SOCLINT	INSTCOM2
.915***	.084	.062	.371 **

THETA EPS

	INSTCOM1	PEERS	ACTIV	RESID	INSTCOM2
INSTCOM1	.000				
PEERS	.000	.000			
ACTIV	.000	.000	.910***		
RESID	.000	.000	.000	.761***	
INSTCOM2	.000	.000	.000	.000	.000

W_A_R_N_I_N_G : THE MATRIX THETA EPS IS NOT POSITIVE DEFINITE

THETA DELTA

MEC	AGE	ETHN
.000	.000	.000

SQUARED MULTIPLE CORRELATIONS FOR Y - VARIABLES

INSTCOM1	PEERS	ACTIV	RESID	INSTCOM2
1.000	1.000	.090	.219	1.000

SQUARED MULTIPLE CORRELATIONS FOR X - VARIABLES

MEC	AGE	ETHN
1.000	1.000	1.000

SQUARED MULTIPLE CORRELATIONS FOR STRUCTURAL EQUATIONS

INSTCOM1	PEERS	SOCLINT	INSTCOM2
.081	.916	.312	.629

TOTAL COEFFICIENT OF DETERMINATION FOR STRUCTURAL EQUATIONS IS .577

MEASURES OF GOODNESS OF FIT FOR THE WHOLE MODEL :

CHI-SQUARE WITH 33 DEGREES OF FREEDOM IS 10.32 (PROB. LEVEL = 1.000)

GOODNESS OF FIT INDEX IS .977

ROOT MEAN SQUARE RESIDUAL IS .042

* $p < .05$

** $p < .01$

*** $p < .001$

Table 10 Estimates for the Community Service Subgroup (modified model)

The model explained large portions of variance in three of the four endogenous variables:

	Certification	Cognitive	Community Service
Social Int	25.6%	25.2%	31.2%
Peers	47.2%	36.7%	91.6%
Inst Com2	45.7%	36.9%	62.9%.

However, the model as detailed here explains very modest proportions of explained variance in the fourth endogenous variable:

Inst Com1	4.1%	2.8%	8.1%.

This initial measure of institutional commitment accounts for much of the variance in the later endogenous variables.

Discussion

Another capability of LISREL which was not discussed here is hypothesis testing. With the estimation of each model a chi-square statistic is provided which tests the goodness of fit of the model for the number of degrees of freedom. A model can be changed slightly, rerun, and the resulting chi-square compared to the first chi-square obtained. The difference in chi-square for the difference in degrees of freedom is a test of the significance of the change to the model. For example, for two of the subgroups in this example, Social Integration is significantly related to the score on the peer relationship scale. For the third subgroup, community service, the relationship is not significant. One may wish to test whether the third relationship is significantly different from the other two. To do so, the researcher would specify through control lines in the program that for the third column and second row of the matrix Beta, values estimated for the three groups be constrained to the same value. The algorithm would then generate the best possible value for the three groups. Finally, the program would be run a third time, freeing the value for the community service subgroup. The chi-square difference between the two models would be a test of whether or not the path is significantly different for the third subgroup (see Wolfle, 1985).

Because of the wide range of possible applications in higher education research, use of LISREL offers an opportunity to expand our capabilities with a tool which is both powerful and flexible. Structural equations, path analysis and factor analysis are among the many techniques that can be applied using LISREL.

LISREL is not well suited to analysis when endogenous variables are not distributed normally. Therefore those studyingpersistence of the average undergraduate population over the freshman year may not find LISREL for explaining persistence. However, those studying first year persistence for special populations (where the distribution of dropouts and persisters is closer to 50-50) may find the algorithm particularly useful. Higher education researchers examining other relationships among dichotomous, ordinal, and continuous variables using theoretical causal models can use LISREL without the assumption violations typically inherent in such work.

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